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Section 9.0 – MCM 1 Class: Vessels with Mine Countermeasure Compression Engines

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SECTION 9.0 – MCM 1 CLASS

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9.0 MCM 1 CLASS

The USS AVENGER Class (MCM 1) was selected to represent the group of operational surface vessels that are medium-sized (400 ≤ displacement < 6000 tons) and diesel powered. The MCM 1 Class is the Navy's latest class of mine countermeasure vessels. With 14 vessels, the MCM is second-largest class in the group. The Army LCU 2000 Class, which is the most abundant class (35 vessels), was not selected because it was estimated to generate half of the bilgewater of the MCM 1 Class. The Coast Guard 175 ft coastal buoy tender KEEPER Class (WLM 175), which also has 14 vessels, was not selected as the representative vessel class for the group because of its very low bilgewater generation rate of 10 gallons per day (gpd). The MCM 1 Class has unique magnetic permeability requirements, however discussion of this requirement is limited to the mission capabilities sections and will not impact the applicability of the analyses to other vessels within the vessel group. MCM 1 Class vessels operate approximately 123 days beyond 12 nautical miles (nm) (Navy and EPA, 2003). The total volume of bilgewater generated within 12 nm is calculated by adding the volume of bilgewater generated in port to the volume generated while operating within 12 nm (e.g., transiting out to 12 nm). MCM 1 Class vessels spend approximately 232 days pierside and another 10 cumulative days in transit, for a total of 242 days within 12 nm of shore annually (Navy and EPA, 2003). The in-port generation rate is 100 gpd and the underway (both transiting and beyond 12 nm) rate is 400 gpd (Navy and EPA, 2003). Each vessel in this class generates approximately 27,200 gallons of bilgewater while within 12 nm and 49,200 gallons of bilgewater beyond 12 nm annually.

Bilgewater generated within 12 nm:

$$\frac{232\text{ days (pierside)}}{\text{yr}} \bullet \frac{100\text{ gal}}{\text{day}} + \frac{10\text{ days (underway)}}{\text{yr}} \bullet \frac{400\text{ gal}}{\text{day}} = 27{,}200\text{ gal/yr}$$

Bilgewater generated beyond 12 nm:

$$\frac{123\text{ days (underway)}}{\text{yr}} \bullet \frac{400\text{ gal}}{\text{day}} = 49{,}200\text{ gal/yr}$$

MCM 1 Class vessels use a 3 gallons per minute (gpm) gravity coalescence type oil water separator (OWS) (Navy model CPS-3 B15) to process bilgewater, consequently this option is the current marine pollution control device (MPCD). MCM 1 Class vessels use one 18-gpm pump to offload either wastewater or waste oil to shore facilities.

Where appropriate, the current MPCD was used to determine the operational capacities and other parameters used to evaluate each of the MPCDs in the feasibility analysis. The following MPCDs are evaluated for MCM 1 Class vessels: gravity coalescence; centrifuge; collection, holding and transfer (CHT); evaporation; hydrocyclone; *in situ* biological treatment; oil absorbing socks; filter media; and membrane filtration.

9.1 GRAVITY COALESCENCE

The following sections discuss the feasibility and cost impacts of installing and operating a gravity coalescence unit on-board a MCM 1 Class vessel.

9.1.1 Practicability and Operational Impact Analysis

This section describes the analyses of specific feasibility criteria relative to the physical characteristics and operational requirements of gravity coalescence.

9.1.1.1 Space and Weight

As described in Section 9.0, the analysis of gravity coalescence will include one 3-gpm gravity coalescence unit (CPS-3) and one 18-gpm pump. The gravity coalescence OWS on-board these vessels is intended for single deck operation and is commonly installed in main or auxiliary machinery spaces, in the vicinity of the oily waste holding tank (OWHT). Table 9-1 provides the space and weight for the CPS-3 B15.

Table 9-1. CPS-3 B15 Specifications (MCM 1 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	3 gpm	2.25 x 2.25 x 2.9	4.3 x 4.3 x 5	15	300/455
Total (To achieve required processing capacity)	1	3 gpm	-	-	15	300/455

9.1.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with gravity coalescence units. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use on-board vessels of the Armed Forces. Standard afloat control and management procedures are adequate for use and disposal of the material. While gravity coalescence units require electrical power, observing standard shipboard safety procedures for handling electrical equipment is adequate.

9.1.1.3 Mission Capabilities

MCM 1 Class vessels are designed to detect and clear mines. Certain mine designs rely on detection of a magnetic signature to trigger detonation. The mine can sense the proximal presence of a ship's magnetic ferrous (steel) hull and detonate itself to cause blast damage to the ship. For this reason, the MCM 1 class hull is constructed of wood. To further ensure that the magnetic signature of the MCM 1 class ship is minimized, certain pieces of equipment that are installed on the ship must meet a magnetic permeability specification (i.e., 2.0 μ). Equipment must be constructed of materials such that its relative magnetic permeability does not exceed the specification. This consideration only applies to the two mine hunter/mine sweeper classes, MCM 1 and MHC 51, in this vessel group. The other vessels in this group do not have this requirement. The CPS-3 B 15 has been tested to ensure its magnetic permeability is within specification. Therefore, the use of the CPS-3 B15 unit on MCM 1 Class vessels does not result in any impact on ship’s signature, war-fighting capabilities, mobility, or on any mission critical systems or operations.

9.1.1.4 Personnel Impact

The time required per year to supervise the operation of the CPS-3 B15 separator is 0.25 hours (15 minutes) for every two hours the unit operates. The supervisory labor requirement of 0.25 hours for every two hours of operation is based on the assumption that although the unit is automatic, a crewmember will be assigned to general oversight of multiple pieces of equipment at once. Based on an MPCD rated capacity of 3 gpm, and the approximate 27,200 gallons of bilgewater generated annually within 12 nm, the annual labor requirement for a gravity coalescence operator is 19 hours.

$$\frac{27{,}200\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{3\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{0.25\text{ hrs labor}}{2\text{ hrs}} = 19\text{ hrs labor/yr}$$

In addition, the waste oil removed from the bilgewater must be transferred to a shore facility. This transfer requires three crewmembers per event. One crewmember is required to operate the waste oil transfer pump and associated valves/hull connections. A second crewmember is required to oversee the connections of transfer hoses for the offloading vessel. A third crewmember oversees the connection of transfer hoses for the receiving vessel or facility. The two crewmembers overseeing the transfer stand near the hose connections in case the connections separate. The two crewmembers also ensure that appropriate precautions are taken to prevent oil spills. During waste oil transfer activities, two-way voice communication must be established between the three crewmembers overseeing the oil transfer (Navy, 2002). The labor hours associated with transferring the waste oil produced by a gravity coalescence unit on MCM 1 Class vessels within 12 nm of shore are calculated by dividing the waste oil volume (1 percent of the bilgewater volume generated within 12 nm of shore) by the waste oil pump rate (18 gpm) and multiplying by the number (three) of crewmembers.

$$\frac{272\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{18\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{3\text{ hrs labor}}{\text{hr}} = 0.76\text{ hrs labor/yr}$$

The combined annual labor requirement aboard an MCM 1 Class vessel for supervising the gravity coalescence unit within 12 nm of shore and oversight of waste oil transfer (for waste oil that is generated within 12 nm) is 20 hours.

The total labor requirement associated with gravity coalescence operation beyond 12 nm includes MPCD operator oversight (i.e., 15 minutes for every two hours of equipment operation) and labor required to oversee the offloading of waste oil to shore attributable to vessel operation beyond 12 nm. The annual labor requirement associated with operating this MPCD beyond 12 nm is calculated using the same methodology used to calculate the annual labor requirement within 12 nm. The volume (i.e., 49,200 gal) of bilgewater generated beyond 12 nm and resultant volume (i.e. 492 gal) of waste oil that requires offloading to shore are based on the MCM 1 Class vessel underway bilgewater generation rate of 400 gpd. The underway generation rate is multiplied by the number of days (123 days) spent beyond 12 nm.

Hours of MPCD operation beyond 12 nm

$$\frac{49{,}200\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{3\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} = 270\text{ hr/yr}$$

Labor requirement for MPCD operator oversight:

$$\frac{270\text{ hrs}}{\text{yr}} \bullet \frac{0.25\text{ hrs labor}}{2\text{ hrs}} = 34\text{ hrs labor/yr}$$

Labor requirement for offloading waste oil:

$$\frac{492\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{18\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{3\text{ hrs labor}}{\text{hrs}} = 1.4\text{ hrs labor/yr}$$

Total MPCD operator labor and waste oil offloading oversight associated with the operation of this vessel class beyond 12 nm is 36 hrs/yr.

Annually, the CPS-3 B15 requires approximately 20.5 personnel hours of time-based maintenance, 0 personnel hours of conditioned based maintenance within 12 nm, and 0 personnel hours of condition-based maintenance beyond 12 nm. Table 9-2 and Table 9-3 summarize the time-based and condition-based maintenance requirements, respectively, for one CPS-3 B15.

Table 9-2. CPS-3 B15 Time-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Remove and Deliver Separator Relief Valve to Test Facility	1	24 months	.5
Clean and Inspect Unit	10	6 months	20
Total Annualize Hours (per unit)	-	-	20.5
Total Annualize Hours (total)	-	-	20.5

Table 9-3. CPS-3 B15 Condition-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on operation hours within 12 nm)	Annualized Maintenance Hours (based on operation hours beyond 12 nm)
None	0	0	0	0
Total Annualized Hours (per unit)	-	-		0
Total Annualized Hours (per vessel)	-	-	-	0

Table 9-4 provides the annual labor hours required to operate and maintain the current MPCD, gravity coalescence.

Table 9-4. Gravity Coalescence Annual Labor Hours (MCM 1 Class)

	CPS-3 B15 Gravity Coalescence
Operator Hours Within 12 nm	20
Operator Hours Beyond 12 nm	36
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance	20.5
Total Time	76

9.1.1.5 Consumables, Repair Parts, and Tools

Gravity coalescence units installed on MCM 1 Class vessels do not require consumables. No special tools are required for the operation or maintenance of these units.

9.1.1.6 Interface Requirements

Table 9-5 summarizes the specific system interface requirements associated with the CPS-3 B15 OWS.

Table 9-5. Gravity Coalescence Interface Requirements (MCM 1 Class)

Shipboard System	CPS-3 B15 Interface Requirements
Electrical Power	0.5 hp, 115/230 VAC/1 phase/60 Hz
Fresh, Salt or Brackish Water	Pressure regulated to 15 psi

9.1.1.7 Control System Requirements

The gravity coalescence units installed on-board the MCM 1 Class are designed to operate in either automatic or manual mode. Automatic operation is the normal operating mode. When placed in the automatic mode, activation of the units is controlled by tank level switches, which are installed in the OWHT. One level switch will start the unit when the liquid level in the tank reaches a pre-set level. A second level switch signals the unit to shut down when the liquid level in the OWHT drops to a pre-set level. Units have a flow sensor that will secure the system if the pump loses suction and a remote alarm/indicator panel, which allows shipboard personnel to monitor the operating status of the units while in the automatic mode of operation. The remote alarm/indicator contains visual indicators that allow operating personnel to monitor the overall status of the system and an audible alarm that warns of system malfunction.

In addition, MCM 1 Class vessels are equipped with an oil content monitor (OCM) to measure the oil content of OWS effluent. If the OCM detects an oil concentration greater than the predetermined desired concentration, the OCM will redirect the effluent back to the OWHT to be retreated by the OWS.

9.1.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

9.1.2 Cost Analysis

The following cost data and calculations are provided to allow the reader to compare relative costs associated with a gravity coalescence system on an MCM 1 Class vessel.

9.1.2.1 Initial Cost

There are no initial costs associated with this MPCD on an MCM 1 Class vessel because the equipment is in place as described above.

9.1.2.2 Recurring Cost

Personnel Labor Within 12 nm

This MPCD requires approximately 40 personnel hours per year for operation, condition-based maintenance, and time-based maintenance within 12 nm, as explained under Section 9.1.1.4. The number of annual labor hours multiplied by the $22.64 hourly MPCD operator labor rate produces the first operating year recurring labor cost within 12 nm.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{40\text{ hrs}}{\text{yr}} = \$910/\text{yr}$$

Personnel Labor Beyond 12 nm

This MPCD requires approximately 36 personnel hours per year for operation beyond 12 nm and condition-based maintenance beyond 12 nm, as explained under Section 9.1.1.4. The annual labor cost associated with operating this MPCD beyond 12 nm is calculated using the same hourly labor rate used to calculate the annual labor cost within 12 nm, as shown below.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{36\text{ hrs}}{\text{yr}} = \$800/\text{yr}$$

The labor required to transfer waste oil generated by the gravity coalescence system to a disposal facility is included in the above labor cost estimates. As explained in Section 1.1.2, the disposal facility is assumed to dispose of the waste oil at no charge for Navy vessels.

Coast Guard vessels pay a fee to dispose of their waste oil. The recurring cost incurred by the Coast Guard to dispose of the waste oil generated within 12 nm is shown below.

$$\frac{272\text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$248/\text{yr}$$

The recurring cost incurred by the Coast Guard to dispose of waste oil generated beyond 12 nm is shown below.

$$\frac{492\text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$448/\text{yr}$$

Table 9-6 summarizes the annual recurring costs for a gravity coalescence system used on an MCM 1 Class vessel.

Table 9-6. Annual Recurring Costs for CPS-3 B15 (MCM 1 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	0.910
Beyond 12 nm	Navy	0.8
Within 12 nm	Coast Guard	1.156
Beyond 12 nm	Coast Guard	1.25

9.1.2.3 Total Ownership Cost (TOC)

Table 9-7 summarizes the TOC and annualized cost over a 15-year lifecycle of a gravity coalescence system on an MCM 1 Class vessel.

Table 9-7. TOC for Gravity Coalescence (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	0	0	0	0
Total Recurring	10.1	19	12.9	26.8
TOC (15-yr lifecycle)	10.1	19	12.9	26.8
Annualized	.861	1.62	1.10	2.279

9.2 CENTRIFUGE

The following sections discuss the feasibility and cost impacts of installing and operating a centrifuge on-board a MCM 1 Class vessel.

9.2.1 Practicability and Operational Impact Analysis

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of centrifuges.

9.2.1.1 Space and Weight

MCM 1 Class vessels are equipped with one 3-gpm gravity coalescing type OWS. One 2-gpm centrifuge unit (Westfalia model OTC-2-03) is being proposed in this analysis. This unit was chosen because it has a processing capacity similar to the current MPCD in place on MCM 1 Class vessels. A major supplier of centrifuges used in the marine industry manufactures the unit and the unit is representative in space, weight, and power requirements of other centrifuges with similar processing capacities. Table 9-8 provides the space and weight for the centrifuge, which comes as a complete 2-gpm module (including one 2-gpm unit and heater).

Table 9-8. Westfalia OTC-2-03 Specifications (MCM 1 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	2 gpm	1.88x1.88x1.96	2.88x2.88x2.96	6.9	132
Total (To achieve required processing capacity)	1	2 gpm	-	-	6.9	132

The centrifuge is designed for single deck operation and would be installed in the current OWS room. The existing OWS would be removed and replaced with the centrifuge unit.

9.2.1.2 Personnel/Equipment Safety

Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use. Standard afloat control and management procedures are adequate for use and disposal of the material. While centrifuges require electrical power, observing standard shipboard safety procedures for handling electrical equipment should be adequate. Integral heaters provided as part of the centrifuge modules preheat the bilgewater to 90°-95° C. However, the heater and associated piping are well insulated and should not pose a burn hazard to personnel (Donohue, 1999).

9.2.1.3 Mission Capabilities

MCM 1 Class vessels are designed to detect and clear mines. Certain mine designs rely on detection of a magnetic signature to trigger detonation. The mine can sense the proximal presence of a ship's magnetic ferrous (steel) hull and detonate itself to cause blast damage to the ship. For this reason, the MCM 1 class hull is constructed of wood. To further ensure that the magnetic signature of the MCM 1 class ship is minimized, certain pieces of equipment that are installed on the ship must meet a magnetic permeability specification (i.e., 2.0 μ). Therefore, equipment must be constructed of materials such that its relative magnetic permeability does not exceed the specification. This consideration only applies to the two mine hunter/mine sweeper classes, MCM 1 and MHC 51, in this vessel group. The other vessels in this group do not have this requirement. The OTC-2-03 has not been tested in order to ensure its magnetic permeability is within specification. If the tests show the OTC-2-03 to have a magnetic permeability greater than two, the unit may have to be redesigned using a larger percentage of non-ferrous materials or another unit that meets the magnetic permeability specification may need to be selected in place of the OTC-2-03 in order not to impact the ship's mission.

9.2.1.4 Personnel Impact

The personnel hours required per year for operation of the centrifuge equals 15 minutes for every two hours the unit operates annually within 12 nm of shore. The supervisory labor requirement of 15 minutes for every two hours of operation is based on the assumption that although the unit is automatic, a crewmember will be assigned to general oversight of multiple pieces of equipment at once. To process the approximate 27,200 gallons of bilgewater generated annually within 12 nm, the number of hours the centrifuge is operated annually within 12 nm is 28 hours.

$$\frac{27{,}200\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{2\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{0.25\text{ hrs labor}}{2\text{ hr}} = 28\text{ hrs labor/yr}$$

In addition, the waste oil removed from the bilgewater must be transferred to a shore facility. This transfer requires three crewmembers per event, as described under Section 9.1.1.4. The labor hours associated with transferring the waste oil produced by a centrifuge unit on an MCM 1 Class vessel within 12 nm of shore are calculated by dividing the waste oil volume (1 percent of the annual bilgewater volume generated within 12 nm of shore) by the waste oil pump rate (18 gpm) and multiplying by the number (three) of crewmembers.

$$\frac{272\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{18\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{3\text{ hrs labor}}{\text{hr}} = 0.76\text{ hrs labor/yr}$$

The total operator labor requirement for the centrifuge aboard the MCM 1 Class vessel within 12 nm of shore equals operator oversight while the centrifuge is running within 12 nm of shore plus waste oil offloading (for waste oil generated within 12 nm of shore) for a total of 29 hours annually. The cost associated with this labor requirement will be analyzed in the cost section.

The total operator labor requirement associated with vessel operation beyond 12 nm includes MPCD operator oversight (i.e., 15 minutes for every two hours of equipment operation) and labor required to oversee the offloading of waste oil to shore attributable to vessel operation beyond 12 nm. The annual labor requirement associated with operating this MPCD beyond 12 nm is calculated using the same methodology used to calculate the annual labor requirement within 12 nm. The volume (i.e., 49,200 gal) of bilgewater generated beyond 12 nm and resultant volume (i.e. 492 gal) of waste oil that requires offloading to shore are based on the MCM 1 Class vessel underway bilgewater generation rate of 400 gpd. The underway generation rate is multiplied by the number of days (123 days) spent beyond 12 nm.

Hours of MPCD operation beyond 12 nm:

$$\frac{49{,}200\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{2.0\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} = 410\text{ hrs/yr}$$

Labor requirement for MPCD operator oversight:

$$\frac{410\,\text{hrs}}{\text{yr}} \bullet \frac{0.25\,\text{hrs}}{2\,\text{hrs}} = 51\,\text{hrs labor/yr}$$

Labor requirement for offloading waste oil:

$$\frac{492\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{18\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{3\text{ hrs labor}}{\text{hrs}} = 1.4\,\text{hrs labor/yr}$$

Total MPCD operator labor and waste oil offloading oversight associated with the operation of this vessel class beyond 12 nm is 53 hrs/yr.

Annually, the OTC-2-03 requires approximately 6.75 personnel hours of time-based maintenance, 0 personnel hours of conditioned based maintenance within 12 nm, and 0 personnel hours of condition-based maintenance beyond 12 nm. Table 9-9 and Table 9-10 summarize the time-based maintenance and the condition-based maintenance requirements, respectively, for one OTC-1-03 centrifuge unit.

Table 9-9. OTC-2-03 Time-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Change gear case oil, renew gaskets	2	6 months	4
Replace drive belt, check bearings	2	12 months	2
Renew sealing rings, replace bearings	1.5	24 months	0.75
Total Annualize Hours (per unit)	-	-	6.75
Total Annualize Hours (total)	-	-	6.75

Table 9-10. OTC-2-03 Condition-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on operation hours within 12 nm)	Annualized Maintenance Hours (based on operation hours beyond 12 nm)
None	0	0	0	0
Total Annualized Hours (per unit)	-	-	-	0
Total Annualized Hours (per vessel)	-	-	-	0

Centrifuges are equipped with programmable logic controls and monitoring systems. The oil content monitor alarm can be monitored remotely or locally.

Operator certification is not required. Inexperienced equipment operators require four to six hours of training. Properly operating centrifuges pose no impact on habitability.

Table 9-11 provides the annual labor hours required to operate and maintain the proposed MPCD discussed in this section.

Table 9-11. Centrifuge Labor Hours (MCM 1 Class)

	MPCD Option: Centrifuge
Operator Hours (hours) Within 12 nm	29
Operator Hours (hours) Beyond 12 nm	53
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance (hours)	6.75
Total Time (hours)	88

9.2.1.5 Consumables, Repair Parts, and Tools

Centrifuges require consumables, repair parts, and special tools. In addition, a spare parts kit is available from the vendor. Consumables and repair parts include items such as filters, gaskets, “O” rings, and bearings. The special tools required are delivered with the machine and consist of spanner wrenches made specifically for dismantling the purifier bowl.

9.2.1.6 Interface Requirements

Table 9-12 lists the interfaces required to support one OTC-2-03 centrifuge.

Table 9-12. OTC-2-03 Interface Requirements (MCM 1 Class)

Shipboard System	OTC-2-03/ 2 gpm
Electrical Power	440VAC/3PH, 0.6 kW
Potable Water	1 gpd

MCM 1 Class vessels are able to accommodate these interface requirements.

9.2.1.7 Control System Requirements

The manufacturer recommends that the operator manually turn on the equipment. However, once the centrifuge has reached its operating speed, the OTC-2-03 does not require constant oversight.

A centrifuge will be equipped with an OCM to measure the oil content of OWS effluent. If the OCM detects an oil concentration greater than the predetermined desired concentration, the OCM will redirect the effluent back to the OWHT to be processed again by the OWS.

9.2.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

9.2.2 Cost Analysis

The following cost data and calculations are provided to allow the reader to compare relative costs associated with a centrifuge system on the MCM 1 Class vessel.

9.2.2.1 Initial Cost

The system (i.e., one unit) procurement cost is $6,520 per vessel (Donohue, 2000). However, if the centrifuge system fails to meet the magnetic permeability specifications required by the MCM 1 and MHC 51 vessel classes, the additional cost required to redesign the system may significantly increase its procurement cost. Based on ship arrangement drawing analysis and an MCM 11 (MCM 1 Class vessel) ship check, the Navy estimates that installation will cost $81,000 per vessel (Navy, 2000). Technical manuals cost approximately $85,000 ($6,071 per vessel) to develop a 150-page manual (Gallagher, 1999). The Navy estimates that the development of technical drawings will cost $22,220 ($1,587 per vessel) (Navy, 2000). The cost for training materials is approximately $9,330 ($666 per vessel) (Smith, 2001). The initial cost of a centrifuge system on an MCM 1 Class vessel is $95,970 per vessel.

9.2.2.2 Recurring Cost

Personnel Labor Within 12 nm

This MPCD requires 36 personnel hours per year for operation, condition-based maintenance, and time-based maintenance within 12 nm, as explained under Section 9.2.1.4. The number of annual labor hours multiplied by the $22.64 hourly MPCD operator labor rate produces the first operating year recurring labor cost within 12 nm.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{36\text{ hrs}}{\text{yr}} = \$810/\text{yr}$$

Personnel Labor Beyond 12 nm

This MPCD requires 53 personnel hours per year for operation, and condition-based maintenance beyond 12 nm, as explained under Section 9.2.1.4. The annual labor cost associated with operating this MPCD beyond 12 nm is calculated using the same hourly labor rate used to calculate the annual labor cost within 12 nm, as shown below.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{53\text{ hrs}}{\text{yr}} = \$1200/\text{yr}$$

The labor required to transfer waste oil generated by the centrifuge to a disposal facility is included in the above labor cost estimates. As explained in Section 1.1.2, the disposal facility is assumed to dispose of the waste oil at no charge to Navy vessels.

Coast Guard vessels pay a fee to dispose of their waste oil. The recurring cost incurred by the Coast Guard to dispose of the waste oil generated within 12 nm is shown below.

$$\frac{272\text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$248/\text{yr}$$

The recurring cost incurred by the Coast Guard to dispose of waste oil generated beyond 12 nm is shown below.

$$\frac{492\text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$448/\text{yr}$$

Table 9-13 summarizes the annual recurring costs for a centrifuge system used on an MCM 1 Class vessel.

Table 9-13. Annual Recurring Costs for OTC-2-03 (MCM 1 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	0.810
Beyond 12 nm	Navy	1.2
Within 12 nm	Coast Guard	1.06
Beyond 12 nm	Coast Guard	1.6

9.2.2.3 Total Ownership Cost (TOC)

Table 9-14 summarizes the TOC and annualized cost over a 15-year lifecycle of a centrifuge system on a MCM 1 Class vessel.

Table 9-14. TOC for Centrifuge (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	96	96	96	96
Total Recurring	8.78	22.1	11.5	29.4
TOC (15-yr lifecycle)	104	118	107	125
Annualized	8.88	10	9.12	10.7

9.3 COLLECTION, HOLDING, AND TRANSFER (CHT)

The following sections discuss the feasibility and cost impacts of not discharging bilgewater (treated or untreated) from MCM 1 Class vessels to the environment within 12 nm from shore. This no-discharge option is referred to as the practice of CHT. For bilgewater generated during operations beyond 12 nm, the bilgewater may be held for transfer to shore facilities while in port, or discharged overboard beyond 12 nm, in accordance with applicable regulations.

NSWCCD Code 20, Total Ship Systems Engineering Group, evaluated the feasibility and cost impacts of practicing CHT of surface vessel bilgewater on small new design vessels powered by diesel engines with wet bilges.

9.3.1 Practicability and Operational Impact Analysis – Existing Vessels

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of CHT.

9.3.1.1 Space and Weight

MCM 1 Class vessels are equipped with an OWHT that has a design capacity of approximately 400 gallons. The holding tank is designed with a capacity 5-10 percent in excess of the ship's requirements, to minimize the risk of overfilling the tanks, which would result in spillage. This tank is designed to collect and hold oily wastewater (i.e., bilgewater) for processing by the vessel's 3-gpm OWS unit or for transfer to shore, as applicable. As such, MCM 1 Class vessels are capable of practicing CHT up to the existing holding capacity without experiencing any impacts to space and weight. The potential for exceeding the vessel's existing space and weight capacities, as a result of practicing CHT, will depend upon the length of time spent within 12 nm from shore, and whether the port visited has the capability to offload wastewater.

During a typical five-year operating cycle, MCM 1 Class vessels may visit many ports for varying lengths of time. The longest stays (i.e., 30 days or more) in port tend to be at the vessel's homeport or at other major Naval ports, where extensive shore services, including wastewater offloading, are available. During these visits, MCM 1 Class vessels typically do not operate their OWS units, but instead transfer their bilgewater to shore facilities. However, to support their operational requirements, MCM 1 Class vessels may occasionally visit smaller non-Navy ports where offloading services are not available. In this situation, an MCM 1 Class vessel could be required to collect and hold all bilgewater generated until the ship is beyond 12 nm or has access to adequate shoreside facilities for disposal. The following paragraphs will evaluate two potential scenarios: (1) arriving at a port where wastewater offloading services are available, and (2) arriving at a port where such services are not available.

Ports with wastewater offloading services: All of the US-based MCM 1 Class vessels are homeported in Ingleside, TX. The four other vessels in this class are homeported in Japan or Bahrain. Ingleside is a major Navy port with complete shore services, including wastewater offloading. Once a vessel has tied up pierside at this port, the transfer of bilgewater to shore can be performed as needed. MCM 1 Class vessels can also collect and hold bilgewater generated while transiting from 12 nm to port for transfer shoreside. The Ingleside homeport is on the coast, where it takes no more than two or three hours to transit between port and 12 nm from shore. While underway, MCM 1 Class vessels generate approximately 400 gpd of bilgewater, or 17 gallons per hour. Using a generation rate of 17 gallons per hour over 3 hours, the maximum volume of bilgewater generated would be approximately 51 gallons. Because the 51 gallons collected during transit is well within the holding capacity for MCM 1 Class vessels, practicing

CHT while transiting to or from a port where shore offloading facilities are available will have no space or weight impacts.

<u>*Port without wastewater offloading services*</u>: If the vessel is visiting a port where offloading bilgewater is not possible, the ship could be required to hold all bilgewater during the entire time spent within 12 nm. A typical visit to a small port may last two to five days. Assuming a five-day port visit, an MCM 1 Class vessel would generate approximately 500 gallons of bilgewater (based on in port generation rate of 100 gpd). Using a generation rate of 17 gallons per hour and a total transit time of 6 hours (3 hours in each direction), the vessel would generate an additional 102 gallons of bilgewater while transiting to and from port. The total bilgewater generated within 12 nm from shore would be 602 gallons. This exceeds the 400-gallon capacity of the existing OWHT, and accommodating this volume would result in adverse space and weight impacts. Under this scenario, an MCM 1 Class vessel would be limited to practicing CHT for up to three days without exceeding its design holding capacity. Using the OWS to process bilgewater from the bilge area as it is generated would decrease the OWS effectiveness. The OWHT acts as a pretreatment that allows the oil content to settle out of the bilgewater thereby allowing the OWS to operate more effectively (Harrington, 1992).

The practice of CHT within the existing holding capacity will not result in any space and weight impacts. However, as demonstrated in the above analysis, there may be situations where practicing CHT may exceed the vessel's holding capacity. This would result in space and weight impacts. Extra tank capacity would be required to accommodate any additional volume of bilgewater collected. Because the space and weight allocations on MCM 1 Class vessels are tightly controlled, there is generally very little available unassigned space to accommodate additional tankage. Therefore, the most likely strategy for increasing bilgewater holding capacity would be to convert other existing tanks to bilgewater holding tanks. However, converting existing tanks to hold bilgewater would likely result in adverse impacts to those systems or services that rely on the tanks being converted for holding oily wastewater.

9.3.1.2 Personnel/Equipment Safety

Practicing CHT within the vessel's existing holding capacity will not pose any safety hazards to the vessel's equipment or crew.

9.3.1.3 Mission Capabilities

Practicing CHT within the vessel's existing holding capacity will not have an impact on ship's signature, war-fighting capabilities, mobility, or on any mission critical systems or operations.

The ship designers review the ship's requirements (e.g., vessel's range, number of crew, etc.) to determine what tank capacities are needed to allow the ship to fulfill its mission. With the exception of approximately five percent excess capacity as a margin of safety, ship designers do not size a vessel's tank capacity beyond what is expected to meet the ship's operating requirements. Practicing CHT in excess of the vessel's existing holding capacity would likely require that additional tanks be built or tanks used for other purposes be converted to bilgewater holding tanks. Reducing the capacity of existing tanks such as potable water tanks, or sewage tanks, will reduce the ship's current capability to support its mission.

The USCG mission often requires their vessels to operate for extended periods of time within 12 nm (e.g., search and rescue missions). The USCG may operate their OWS, as necessary and at the discretion of the Commanding Officer, to prevent bilgewater accumulation in excess of the vessels' current holding capacity and minimize mission impacts. In instances where an USCG vessel is at risk of exceeding its bilgewater holding capacity (e.g., during extensive operations within 12 nm), requiring USCG vessels to practice CHT without the flexibility of processing bilgewater through the OWS would have a significant mission impact. Specifically, if an USCG vessel were required to practice CHT and was at risk of exceeding its current holding capacity, it would have to return to shore to offload bilgewater thus forcing the vessel to discontinue critical mission-related activities.

9.3.1.4 Personnel Impact

Practicing CHT within the vessel's existing holding capacity will not result in any personnel impacts other than time required to oversee the transfer of bilgewater and oily waste to shore (see analysis below).

Practicing CHT as a primary control option does not require additional special training. Manning is required to oversee the transfer of bilgewater to a shore facility or receiving vessel [i.e., operate the oily waste transfer (OWT) pump and associated valves/hull connections]. This transfer requires three crewmembers per event, as described in Section 9.1.1.4. The MCM 1 Class vessels generate 27,200 gallons of bilgewater annually within 12 nm. The annual volume of bilgewater generated within 12 nm of shore divided by the OWT pump rate (18 gpm), multiplied by the number (three) of people required for oversight, equals the personnel hours required per year for CHT on the MCM 1 Class.

$$\frac{27{,}200\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{18\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} \bullet \frac{3\ \text{hrs labor}}{\text{hr}} = 76\ \text{hrs labor/yr}$$

Table 9-15 provides the annual labor hours required for CHT.

Table 9-15. CHT Labor Hours (MCM 1 Class)

	MPCD Option: CHT
Operator Hours Within 12 nm	76
Operator Hours Beyond 12 nm	-
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	-
Time-based Maintenance	0
Total Time	76

9.3.1.5 Consumables, Repair Parts, and Tools

There are no requirements for consumables, repair parts, or tools associated with CHT.

9.3.1.6 Interface Requirements

Practicing CHT does not require any unique interface requirements. OWT pumps and associated valves, piping, and hull connections exist on this vessel class to support the current practice of shoreside disposal.

9.3.1.7 Control System Requirements

There are no automated control system requirements associated with CHT. However, crewmembers are required by OPNAVINST 5090.1 (series) to watch for oily wastewater spills (e.g., during shoreside transfers) (Navy, 2002).

9.3.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

9.3.2 Cost Analysis – Existing Vessels

The following cost data and calculations are provided to allow the reader to compare relative costs associated with practicing CHT on an MCM 1 Class vessel. Since the practice of CHT only applies to vessel operations within 12 nm from shore, there is no cost associated with CHT beyond 12 nm from shore. Therefore, CHT costs are calculated for operations within 12 nm only. Vessels in this class will continue to comply with appropriate regulations when operating beyond 12 nm.

9.3.2.1 Initial Cost

As described in the previous section, the reallocation of tank space to increase bilgewater holding capacity on an MCM 1 Class vessel would result in adverse impacts on mission capabilities and personnel. For the cost analysis, it was assumed that current bilgewater holding capacity will not be modified. Therefore, the initial cost of acquisition and installation of additional equipment, such as tankage and piping systems, is assumed to be zero.

9.3.2.2 Recurring Cost

MCM 1 Class vessels require 76 personnel hours per year for the transfer of oily waste to shore, as explained under Section 9.2.1.4. The annual labor hours multiplied by the $22.64 per hour MPCD operator labor rate produces the first operating year recurring labor cost of $1,700.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{76\text{ hrs}}{\text{yr}} = \$1{,}700/\text{yr inside 12 nm}$$

The annual bilgewater generation rate within 12 nm is 27,200 gallons. Multiplying the volume of bilgewater generated annually within 12 nm by the oily waste disposal unit cost produces the annual recurring disposal cost for CHT on a MCM 1 Class vessel of $2,037.

$$\frac{27{,}200\text{ gal}}{\text{yr}} \bullet \frac{\$0.0749}{\text{gal}} = \$2{,}037\text{ /yr}$$

To determine the waste disposal cost for Coast Guard vessels within this vessel group, the volume of bilgewater generated annually within 12 nm multiplied by the oily waste disposal unit cost for Coast Guard vessels produces the annual recurring disposal cost for CHT on a similar Coast Guard vessel of $24,750.

$$\frac{27{,}200 \text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$24{,}750/\text{yr}$$

Table 9-16 summarizes the annual recurring costs of using CHT on an MCM 1 Class vessel.

Table 9-16. Annual Recurring Costs for CHT (MCM 1 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	3.75
Beyond 12 nm	Navy	-
Within 12 nm	Coast Guard	26.46
Beyond 12 nm	Coast Guard	-

9.3.2.3 Total Ownership Cost (TOC)

Table 9-17 summarizes the TOC and annualized cost over a 15-year lifecycle for CHT on an MCM 1 Class vessel.

Table 9-17. TOC for CHT (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	0	0	0	0
Total Recurring	41.8	41.8	294.9	294.9
TOC (15-yr lifecycle)	41.8	41.8	294.9	294.9
Annualized	3.55	3.55	25.06	25.06

9.3.3 Practicability and Operational Impact Analysis – New Design Vessels

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of practicing CHT on new design vessels.

9.3.3.1 Space and Weight

Ports with wastewater offloading services: As discussed in Section 9.3.1.1, practicing CHT while tied up pierside or transiting to or from a port where shore offloading facilities are available (assuming a total maximum transit time of six hours) will have no space or weight impacts.

Ports without wastewater offloading services: As discussed in Section 9.3.1.1, the current holding capacity of the OWHT (400 gallons) is not sufficient to hold all bilgewater generated during an extended port visit (typically two to five days) at a port where shore offloading facilities are not available. Based on typical operating scenarios and bilgewater generation rates, NSWCCD Code 20 determined that a tank (or series of tanks) with a capacity of approximately 660 gallons would be required to hold all bilgewater generated during an extended port visit. This is approximately 65 percent larger than the existing OWHT capacity and is a 0.99 percent increase in total dead weight. To support this additional tank volume, the size of the ship must be increased. Increasing the ship's size to support this additional dead weight will require approximately 1.2 long tons (LT) of additional structure, resulting in a total weight increase of approximately 2.2 LT and approximately 4.2 inches in overall ship length. This increase represents a 0.2 percent increase in full load weight over a current MCM 1 Class vessel. Furthermore, the additional structure required to accommodate a larger CHT system would increase the ship's volume by approximately 300 ft^3, of which only 35 ft^3 (approximately 12 percent) would be occupied by the CHT system (Navy, 2003d).

9.3.3.2 Personnel/Equipment Safety

Practicing CHT within the vessel's holding capacity on new design vessels will not pose any safety hazards to vessel equipment or crew.

9.3.3.3 Mission Capabilities

Practicing CHT within the vessel's existing holding capacity will not impact the mission-related operational capability of Navy vessels as long as they are not required to remain on station within 12 nm of shore for more than 30 hours while underway, or five days when in port (time it would take to fill the proposed CHT system) (Navy, 2003d).

Operational scenarios do exist for MCM 1 Class vessels (minesweeper vessels) that would require that they operate in shallow coastal waters for extended periods of time. MCM 1 Class vessels would be unable to practice CHT in excess of their holding capacity in these scenarios because of the potential impact to the ship's ability to meet critical mission-related activities (Navy, 2003d).

Additionally, Code 20 concluded that providing a larger CHT system is recommended, provided the increase in CHT capacity will be sufficient to satisfy the operational requirements of the vessel's mission profile (Navy, 2003d).

9.3.3.4 Personnel Impact

Practicing CHT would require approximately three crewmembers per event to conduct the transfer of oily wastes to shoreside facilities. Practicing CHT on new design vessels is expected to require 76 total hours of labor per year (Navy, 2003d).

9.3.3.5 Consumables, Repair Parts, and Tools

There are no requirements for consumables, repair parts, or tools associated with practicing CHT on new design vessels.

9.3.3.6 Interface Requirements

Practicing CHT on new design vessels will not have an impact on interface requirements. No additional load would be placed on the ship's electrical plant (Navy, 2003d).

9.3.3.7 Control System Requirements

There are no automated control system requirements associated with CHT. However, crewmembers are required by OPNAVINST 5090.1 (series) to watch for oily wastewater spills (e.g., during shoreside transfers) (Navy, 2002).

9.3.3.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to practicing CHT on new design vessels.

9.3.4 Cost Analysis – New Design Vessels

The following cost data and calculations are provided to allow the reader to compare relative costs associated with practicing CHT on a new design vessel in this vessel group. CHT is generally not practiced beyond 12 nm from shore; therefore, CHT costs are calculated for operation within 12 nm only. Vessels in this class must continue to comply with appropriate regulations when operating beyond 12 nm.

NSWCCD Code 20 estimated the total initial, total recurring, TOC, and annualized costs for practicing CHT on new design vessels in this vessel group. Table 9-18 summarizes those costs below.

9.3.4.1 Initial Cost

The required increase in OWHT volume (660 gallons vs. 400 gallons) would require new design vessels in this vessel group to add 1.2 LTs of additional steel, adding approximately $30,000 to the initial acquisition cost of each ship (Navy, 2003d).

9.3.4.2 Recurring Cost

Practicing CHT requires 76 total labor hours per year for operation, as explained in Section 9.3.3.4. The labor and disposal costs associated with bilgewater disposal are estimated to be $3,750 annually for the Navy (Navy, 2003d).

The labor and disposal costs associated with bilgewater disposal are estimated to be $26,500 annually for the Coast Guard.

9.3.4.3 Total Ownership Cost (TOC)

Table 9-18 summarizes the TOC and annualized cost of practicing CHT on an MCM 1 Class vessel.

Table 9-18. TOC for CHT System on New Design Vessels (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	30.0	30.0	30.0	30.0
Total Recurring	41.8	41.8	295	295
TOC (15-yr lifecycle)	71.5	71.5	325	325
Annualized	6.1	6.1	27.6	27.6

9.4 EVAPORATION

Based on the review of ship drawings, the Navy's Alteration and Installation Team (AIT) has concluded that there is not adequate space on the MCM 1 Class vessel to reconfigure equipment to accommodate an evaporation system sufficient for processing the bilgewater generation rate (Navy, 2000). Therefore, no further analysis will be conducted with regard to the use of an evaporation system on MCM 1 Class vessels. Furthermore, despite the flexibility afforded by new design vessels (e.g., reduced cost of forward-fit installation), new design vessels are not expected to be able to support the evaporators' substantial power requirements. In addition, design concerns such as corrosivity, plating out of salt in the unit, and buildup of salt and sludge still need to be addressed before this technology may be feasible on this vessel class.

9.5 HYDROCYCLONES

The following sections discuss the feasibility and cost impacts of installing and operating a hydrocyclone on-board an MCM 1 Class vessel.

9.5.1 Practicability and Operational Impact Analysis

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of hydrocyclones.

9.5.1.1 Space and Weight

MCM 1 Class vessels are equipped with one 3-gpm gravity coalescing type OWS. One 4-gpm hydrocyclone (Krebs model Spinifex 1000) is proposed for this analysis. This unit was chosen because it has a processing capacity similar to the current MPCD in place on MCM 1 Class vessels and is representative in space, weight, and power requirements of hydrocyclones with similar processing capacities. Table 9-19 provides the space and weight of a Spinifex 1000 Module (4 gpm) consisting of a strainer basket, air operated diaphragm pump, and interconnecting piping.

Table 9-19. Hydrocyclone Specifications (MCM 1 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	4 gpm	2.33 x 0.92 x 3.67	3 x 2 x 7	8	88/100
Total (To achieve required processing capacity)	1	4 gpm	-	-	8	88/100

The hydrocyclone module is designed for single-deck operation and would be installed in the current OWS room. The existing OWS would be removed and replaced with the new hydrocyclone module.

9.5.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with hydrocyclones. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use. Standard afloat control and management procedures are adequate for use and disposal of the material. While hydrocyclones require pressurized air to operate, observing standard shipboard safety procedures for handling compressed air systems should be adequate.

9.5.1.3 Mission Capabilities

MCM 1 Class vessels are designed to detect and clear mines. Certain mine designs rely on detection of a magnetic signature to trigger detonation. The mine can sense the proximal presence of a ship's magnetic ferrous (steel) hull and detonate itself to cause blast damage to the ship. For this reason, the MCM 1 class hull is constructed of wood. To further ensure that the magnetic signature of the MCM 1 class ship is minimized, certain pieces of equipment that are installed on the ship must meet a magnetic permeability specification (i.e., 2.0 μ). Therefore, equipment must be constructed of materials such that its relative magnetic permeability does not exceed the specification. This consideration only applies to the two mine hunter/mine sweeper classes, MCM 1 and MHC 51, in this vessel group. The other vessels in this group do not have this requirement. The Spinifex 1000 has not been tested in order to ensure its magnetic permeability is within specification. If the tests show the Spinifex 1000 to have a magnetic permeability greater than two, the unit may have to be redesigned using a larger percentage of non-ferrous materials or another unit that meets the magnetic permeability specification may need to be selected in place of the Spinifex 1000 in order not to impact the ship's mission.

9.5.1.4 Personnel Impact

The hydrocyclone unit runs in automatic mode, but still requires general supervision while the unit is operating. Based on an MPCD rated capacity of 4 gpm and the 27,200 gallons of bilgewater generated annually within 12 nm, the number of hours the hydrocyclone would be operated annually within 12 nm is 113.

$$\frac{27{,}200\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{4\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} = 113\ \text{hrs/yr}$$

As described under Section 9.1.1.4, 15 minutes (0.25 hours) of general oversight for every two hours of operation is assumed. To process the 27,200 gallons of bilgewater generated annually within 12 nm, 14 hours of oversight will be required per year.

$$\frac{113\ \text{hrs}}{\text{yr}} \bullet \frac{0.25\ \text{hrs labor}}{2\ \text{hrs operation}} = 14\ \text{hrs labor/yr}$$

In addition, the waste oil removed from the bilgewater must be transferred to a shore facility. This transfer requires three crewmembers per event as described under Section 9.1.1.4. The labor hours associated with transferring the waste oil produced within 12nm of shore are calculated by dividing the waste oil volume (1 percent of the annual volume of bilgewater generated within 12 nm of shore) by the waste oil pump rate (18 gpm) and multiplying by the number (three) of crewmembers. As calculated below, the labor requirement for a hydrocyclone is .76 hours of labor per year for offloading waste oil generated within 12 nm of shore.

$$\frac{272\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{18\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} \bullet \frac{3\ \text{hrs labor}}{\text{hr}} = 0.76\ \text{hrs labor/yr}$$

The combined annual labor associated with the operational oversight of the hydrocyclone within 12 nm and transfer of waste oil generated within 12 nm on a MCM 1 class vessel is 15 hours.

The total labor requirement associated with vessel operation beyond 12 nm includes MPCD operator oversight (i.e., 15 minutes for every two hours of equipment operation), and labor required to oversee the offloading of waste oil to shore attributable to vessel operation beyond 12 nm. The annual labor requirement associated with operating this MPCD beyond 12 nm is calculated using the same methodology used to calculate the annual labor requirement within 12 nm. The volume (i.e., 49,200 gal) of bilgewater generated beyond 12 nm and resultant volume (i.e. 492 gal) of waste oil that requires offloading to shore are based on the MCM 1 Class vessel underway bilgewater generation rate of 400 gpd. The underway generation rate is multiplied by the number of days (123 days) spent beyond 12 nm.

Hours of MPCD operation beyond 12 nm

$$\frac{49{,}200\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{4\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} = 205\ \text{hrs/yr}$$

Labor requirement for MPCD operator oversight:

$$\frac{205\ \text{hrs}}{\text{yr}} \bullet \frac{0.25\ \text{hrs}}{2\ \text{hrs}} = 26\ \text{hrs labor/yr}$$

Labor requirement for offloading waste oil:

$$\frac{492\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{18\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{3\text{ hrs labor}}{\text{hrs}} = 1.4\text{ hrs labor/yr}$$

Total MPCD operator labor and waste oil offloading oversight associated with the operation of this vessel class beyond 12 nm is 27 hr/yr.

Annually, the hydrocyclone requires approximately 1.5 personnel hours of time-based maintenance, 0 personnel hours of condition-based maintenance within 12 nm, and 0 hours of personnel hours of condition-based maintenance beyond 12 nm. Table 9-20 and Table 9-21 summarize the time-based and condition-based maintenance requirements, respectively, for one hydrocyclone.

Table 9-20. Hydrocyclone Time-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Clean and Inspect Strainer Basket	0.25	3 months	1
Inspect Air Diaphragm Pump for Wear	0.25	12 months	0.25
Replace Air Diaphragm	0.25	12 months	0.25
Total Annualized Hours	-	-	1.5

Table 9-21. Hydrocyclone Condition-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on operation hours within 12 nm)	Annualized Maintenance Hours (based on operation hours beyond 12 nm)
None	0	0	0	0
Total Annualized Hours	-	-	-	0

Table 9-22 provides the annual labor hours required for operation and maintenance of the proposed MPCD in this section.

Table 9-22. Hydrocyclone Annual Labor Hours (MCM 1 Class)

	MPCD Option: Hydrocyclone
Operator Hours Within 12 nm	15
Operator Hours Beyond 12 nm	27
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance	1.5
Total Time	43

Hydrocyclones do not have an impact on habitability. Hydrocyclones are closed systems, so no vapors are present. Manning requirements will be minimal because the hydrocyclones require very little maintenance, and operation can be fully automated. Periodic monitoring of the inlet and underflow pressures would be recommended to evaluate operating conditions and determine if maintenance is needed.

9.5.1.5 Consumables, Repair Parts, and Tools

Consumables and repair parts, which should be on hand, include "O" rings and gaskets for the cyclone, a few spare cyclone liners, and some components (replacement diaphragm, etc.,) for the pump.

9.5.1.6 Interface Requirements

Table 9-23 summarizes the specific system interface requirement associated with the hydrocyclones.

Table 9-23. Hydrocyclone Interface Requirements (MCM 1 Class)

Shipboard System	4 gpm
Compressed Air	12 scfm @ 65 psi

MCM 1 Class vessels are able to accommodate this interface requirement.

9.5.1.7 Control System Requirements

Hydrocyclones are generally designed to operate in either automatic or manual mode. Automatic operation is the normal operating mode. When placed in the automatic mode, activation of the units is controlled by tank level switches, which are installed in the OWHT. One level switch will start the unit(s) when the liquid level in the tank reaches a pre-set level. When the liquid level in the OWHT drops to a pre-set level, a second level switch signals the unit(s) to shut down. Units have a flow sensor that will secure the system if the pump loses suction and a remote alarm/indicator panel, which would allow shipboard personnel to monitor the operating status of the units while in the automatic mode of operation.

9.5.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

9.5.2 Cost Analysis

The following cost data and calculations are provided to allow the reader to compare relative costs associated with the hydrocyclone on an MCM 1 Class vessel.

9.5.2.1 Initial Cost

The system (i.e., one unit) procurement cost is $5,603 per vessel (Lima, 2000). However, if the hydrocyclone system fails to meet the magnetic permeability specifications required by the MCM 1 and MHC 51 vessel classes, the additional cost required to redesign the system may significantly increase its procurement cost. Based on ship arrangement drawing analysis and an MCM 11 (MCM 1 Class vessel) ship check, the Navy estimates that installation will cost $79,000 per vessel (Navy, 2000). Technical manuals cost approximately $85,000 ($6,071 per vessel) to develop a 150-page manual (Gallagher, 1999). The Navy estimates that the development of technical drawings will cost $22,220 ($1,587 per vessel) (Navy, 2000). The cost for training materials is approximately $9,330 ($666 per vessel) (Smith, 2001). The initial cost of a hydrocyclone system on an MCM 1 Class vessel is $93,000 per vessel.

9.5.2.2 Recurring Cost

Personnel Labor Within 12 nm

This MPCD requires 16 personnel hours per year for operation, condition-based maintenance, and time-based maintenance within 12 nm, as explained under Section 9.5.1.4. The number of annual labor hours multiplied by the $22.64 hourly MPCD operator labor rate produces the first operating year recurring labor cost within 12 nm.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{16\ \text{hrs}}{\text{yr}} = \$372\ /\text{yr inside } 12\ \text{nm}$$

Personnel Labor Beyond 12 nm

This MPCD requires 27 personnel hours per year for operation, and condition-based maintenance beyond 12 nm, as explained under Section 9.5.1.4. The annual labor cost associated with operating this MPCD beyond 12 nm is calculated using the same hourly labor rate used to calculate the annual labor cost within 12 nm, as shown below

$$\frac{27\ \text{hrs}}{\text{yr}} \bullet \frac{\$22.64}{\text{hr}} = \$611\ /\text{yr inside } 12\ \text{nm}$$

The bilgewater generated annually within 12 nm multiplied by the oily waste disposal unit cost for Coast Guard vessels produces the annual recurring disposal cost for a hydrocyclone system on a MCM 1 vessel of $248.

$$\frac{272 \text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$248/\text{yr}$$

The recurring cost incurred by the Coast Guard to dispose of waste oil generated beyond 12 nm is shown below.

$$\frac{492 \text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$448/\text{yr}$$

Table 9-24 summarizes the annual recurring costs of using a hydrocyclone system on an MCM 1 Class vessel.

Table 9-24. Annual Recurring Costs for Hydrocyclone (MCM 1 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	0.372
Beyond 12 nm	Navy	.611
Within 12 nm	Coast Guard	0.619
Beyond 12 nm	Coast Guard	1.059

9.5.2.3 Total Ownership Cost (TOC)

Table 9-25 summarizes the TOC and annualized cost over a 15-year lifecycle of a hydrocyclone system on an MCM 1 Class vessel.

Table 9-25. TOC for Hydrocyclone (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	93	93	93	93
Total Recurring	4.15	11	6.9	18.7
TOC (15-yr lifecycle)	97	104	99.9	112
Annualized	8.3	8.83	8.49	9.49

9.6 *IN SITU* BIOLOGICAL TREATMENT

In situ biological treatment of bilgewater is the addition of microbes to a vessel's bilge spaces to digest the oil content of the bilgewater. For *in situ* biological treatment to be effective, the microbes must be left in the bilge for a sufficient period of time to digest the bilgewater's oil content. According to the vendor, the most effective use of in situ biological treatment for the wastewater that accumulates in the bilge is to leave the *in situ* material in the bilge spaces on the vessel for a 30-day period to establish a population of microbes (Opsanick, 2000). Transferring bilgewater to shore or allowing additional bilgewater to be introduced to the bilge spaces before the 30-day period is complete may decrease the *in situ* biological treatment's effectiveness. Due to the lack of performance data, the extent to which the effectiveness of biological treatment would be decreased cannot be determined (Opsanick, 2000). However, the vessel would be continuously generating bilgewater during this period, disrupting the batch processing method recommended by the manufacturer. Further, the vessel's total bilgewater generation over a 30-day period is at least 3,000 gallons. Leaving this volume of bilgewater in the bilge spaces to allow more complete treatment would inhibit the safe operation of existing or new design vessels. Therefore, *in situ* biological treatment is not a feasible MPCD option group for existing or new design vessels represented by MCM 1 Class vessels.

9.7 OIL ABSORBING SOCKS (OASS)

OASs are designed to absorb oil floating on the surface of a body of water (Sorbent Products, Inc., 2000). In this application, OASs would be placed inside the bilge areas of an MCM 1 Class vessel to continuously absorb the waste oil from the bilgewater. When the OAS becomes fully saturated, they are manually removed and replaced with a new OAS. This use of OASs for MCM 1 Class vessels poses concerns regarding the generation of solid waste, the potential to affect emergency dewatering, and as a potential fuel source that could contribute to the intensity of a fire involving the bilge spaces.

The presence of OASs in the bilge spaces would potentially restrict the flow of bilgewater through the normal and emergency dewatering pumps and strainers by clogging the suction points. The use of OASs in the bilge spaces of both U.S. Coast Guard and Navy vessels would not be feasible due to vessel safety and survivability concerns. Both services prohibit (through practice) the presence of any loose materials or debris in the bilge areas that could potentially interfere with normal or emergency dewatering activities. Securing the OASs to a pipe or other type of fixture in the bilge is not feasible because the force of a shock or explosion would potentially dislodge the OAS. Furthermore, as the OAS absorbs oil it becomes a concentrated fuel source that could contribute to the intensity of a fire involving the bilge spaces.

Based on the potential operational and safety impacts related to emergency dewatering, and potential fire hazards, OASs are not a feasible MPCD option group on MCM 1 Class vessels. New design vessels cannot resolve these impacts.

9.8 FILTER MEDIA

The following sections discuss the feasibility and cost impacts of installing and operating a filter media secondary OWS system on-board an MCM 1 Class vessel. Secondary OWS systems treat the effluent from the primary OWS.

9.8.1 Practicability and Operational Impact Analysis – Existing Vessels

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of filter media systems.

9.8.1.1 Space and Weight

One 10-gpm filter media polisher is proposed in this analysis. The polishing unit consists of oil absorbing filter media canisters and is designed to treat the OWS effluent before being discharged overboard. Although the 10-gpm unit exceeds the capacity requirements of the current MPCD, the 10-gpm unit is the smallest commercially available filter media system. This filter media system has also been tested on-board two DDG 51 Class destroyers. The OWS filter media polisher installed on-board these vessels is intended for single-deck operation and is commonly placed in main or auxiliary machinery spaces, in the vicinity of the OWS. The polisher is comprised of three cylindrical tanks, installed in a triangular pattern, each containing three canisters filled with oil absorbing media. The proposed 10-gpm unit would be installed in the pump room adjacent to the engine room. Relocation of piping, furniture and equipment would be required to provide an installation envelope (Navy, 2000). Table 9-26 provides the approximate space and weight of the 10-gpm unit (Navy, 2003e).

Table 9-26. Filter Media Polisher Specifications (MCM 1 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	10 gpm	3.6 x 2.5 x 4	5.2 x 4 x 5.25	36	1320/1900
Total (To achieve required processing capacity)	1	10 gpm	-	-	36	1320/1900

Because the MCM 1 Class is in weight critical status (i.e., the initial design margin for accommodating additional weight from new equipment is almost completely used) each individual vessel within the class will have to be analyzed to determine whether it can support a secondary MPCD (Navy, 2000).

9.8.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with this MPCD. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use. Standard afloat control and management procedures are adequate for use and disposal of the material.

9.8.1.3 Mission Capabilities

MCM 1 Class vessels are designed to detect and clear mines. Certain mine designs rely on detection of a magnetic signature to trigger detonation. The mine can sense the proximal presence of a ship's magnetic ferrous (steel) hull and detonate itself to cause blast damage to the ship. For this reason, the MCM 1 Class hull is constructed of wood. To further ensure that the magnetic signature of the MCM 1 Class vessel is minimized, certain pieces of equipment that are installed on the ship must meet a magnetic permeability specification (i.e., 2.0 μ). Therefore, equipment must be constructed of materials such that its relative magnetic permeability does not exceed the specification. This consideration only applies to the two mine hunter/mine sweeper classes, MCM 1 and MHC 51, in this vessel group. The other vessels in this group do not have this requirement. The filter media system has not been tested in order to ensure its magnetic permeability is within specification. If the tests show the filter media system to have a magnetic permeability greater than two, the unit may have to be redesigned using a larger percentage of non-ferrous materials so that is does not impact the ship's mission.

9.8.1.4 Personnel Impact

It is assumed that because a secondary OWS unit runs in conjunction with a primary OWS unit, the secondary unit will not require significant additional oversight. Therefore, operator oversight hours associated with secondary units are assumed to be zero.

The recovered waste oil is absorbed into filter media canisters that must be offloaded. The time required to replace the filter media canisters is 1 hour for each unit. Because MCM 1 is equipped with one unit, the total time required to replace the filter media canisters is one hour. The filter media canisters have to be replaced every 400 hours of operation (Galecki, 2000). With a total rated capacity of 10 gpm and a total of 26,930 gallons of effluent to be processed annually within 12 nm (equal to bilgewater generated annually within 12 nm minus 1 percent of oil removed by the primary OWS), the filter media will have to operate 45 hours per year to process the bilgewater generated within 12 nm. Therefore, the filter media will have to be replaced every 9 years due to operation within 12 nm. The annual number of hours spent replacing the filter media canisters is 0.11 hours per year.

$$\frac{26{,}930\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{10\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{1\text{ hrs}}{400\text{ hrs}} = 0.11\,\text{hrs labor/yr}$$

Annually, the filter media canisters require approximately 0 personnel hours of time-based maintenance, and .11 personnel hours of condition-based maintenance within 12 nm. Table 9-27 and Table 9-28 summarize the time-based maintenance and the condition-based maintenance requirements, respectively, for a filter media unit.

Table 9-27. Filter Media Time-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
None	0	0	0
Total Annual Labor per unit	-	-	0
Total Annual Labor per vessel	-	-	0

Table 9-28. Filter Media Condition-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on 45 operation hours within 12 nm)	Annualized Maintenance Hours (based on 0 operation hours beyond 12 nm)
Replace Filter Media Canisters	5	400	0.11	0
Total Annualized Hours	-	-	.11	0

Table 9-29 provides the annual labor hours required to maintain the MPCD option discussed in this section.

Table 9-29. Filter Media Annual Labor Hours (MCM 1 Class)

	MPCD Option: Filter Media
Operator Hours Within 12 nm	0
Operator Hours Beyond 12 nm	0
Condition-based Maintenance Within 12 nm	0.11
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance Within 12 nm	0
Time-based Maintenance Beyond 12 nm	0
Total Time	0.11

9.8.1.5 Consumables, Repair Parts, and Tools

The OWS filter media polishing unit will require the replacement of nine filter media canisters. The canisters may be stored on the vessel or shore side. No special repair parts or tools are required for the operation or maintenance of these units.

9.8.1.6 Interface Requirements

No specific system interface requirements are associated with the OWS filter media polishing unit.

9.8.1.7 Control System Requirements

The OWS filter media polishing system operates automatically in response to the primary OWS operation. Therefore, the polisher unit does not have any unique control system requirements.

9.8.1.8 Other/Unique Characteristics

The OWS filter media polishing systems were installed on two DDG 51 Class destroyers. However, these systems were removed because they failed to consistently produce an effluent with an oil content less than 15 parts per million (Hopko, 1996). Navy ships with OWSs and Oil

Content Monitors should attempt to limit oil and oily discharges to 15 ppm oil worldwide (Navy, 2002).

9.8.2 Cost Analysis – Existing Vessels

The following cost data and calculations are provided to allow the reader to compare costs associated with a filter media system on the MCM 1 Class vessel.

9.8.2.1 Initial Cost

The system (i.e., one unit) procurement cost is $15,675 per vessel (Hanrahan, 1997). However, if the filter media system fails to meet the magnetic permeability specifications required by the MCM 1 and MHC 51 vessel classes, the additional cost required to redesign the system may significantly increase its procurement cost. Based on ship arrangement drawing analysis and an MCM 11 (MCM 1 Class vessel) ship check, the Navy estimates that installation will cost $70,000 per vessel (Navy, 2000). Technical manuals cost approximately $85,000 ($6,071 per vessel) to develop a 150-page manual (Gallagher, 1999). The Navy estimates that the development of technical drawings will cost $22,220 ($1,587 per vessel) (Navy, 2000). The cost for training materials is approximately $9,330 ($666 per vessel) (Smith, 2001). The initial cost of a filter media system on a MCM 1 Class vessel is $94,000 per vessel.

9.8.2.2 Recurring Cost

The filter media system requires 0.11 personnel hours per year for condition-based maintenance within 12 nm, as explained under Section 9.8.1.4. The annual labor hours multiplied by the $22.64 per hour MPCD operator labor rate produces the first operating year recurring labor cost of $3/yr.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{0.11\ \text{hrs}}{\text{yr}} = \$3/\text{yr}$$

The replacement cost of filter media canisters due to operation within 12 nm is $7,300/unit. The filter media canisters must be replaced after approximately 400 hours of operation (Galecki, 2000). With a total rated capacity of 10 gpm and a total of 26,930 gallons of effluent to be processed annually within 12 nm, the filter media will have to operate approximately 45 hours per year. Therefore, the filter media will have to be replaced after 9 years, which results in an annual cost of $820.

$$\frac{26{,}930\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{10\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} \bullet \frac{1\ \text{replacement}}{400\ \text{hrs}} \bullet \frac{\$7{,}300}{\text{replacement}} = \$820/\text{yr}$$

The filter media canisters are combined and disposed of with the vessels' solid waste. Because of the relative infrequency and small volumes disposed, the Navy does not expect any significant increase in their overall solid waste disposal cost.

The filter media canisters absorb the oil content of the oily bilge water. Because media canisters absorb the oil content, the filter media system does not produce waste oil that must be offloaded from the vessel. Table 9-30 summarizes the annual recurring costs for a filter media system used on a MCM 1 Class vessel.

Table 9-30. Annual Recurring Costs for Filter Media (MCM 1 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	0.82
Beyond 12 nm	Navy	-
Within 12 nm	Coast Guard	0.82
Beyond 12 nm	Coast Guard	-

9.8.2.3 Total Ownership Cost (TOC)

Table 9-31 summarizes the TOC and annualized cost over a 15-year lifecycle for a filter media system on an MCM 1 Class vessel.

Table 9-31. TOC for Filter Media (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	94	94	94	94
Total Recurring	9.16	9.16	9.16	9.16
TOC (15-yr lifecycle)	103	103	103	103
Annualized	8.77	8.77	8.77	8.77

9.8.3 Practicability and Operational Impact Analysis – New Design Vessels

The practicability and operational impact of using filter media systems on new design vessels in this vessel group are expected to be similar to the impact on existing vessels in this group, as represented by MCM 1 Class vessels. The installation cost would be different for new design vessels, however all other costs are not expected to change. Therefore, except for the installation cost and the adjusted TOC, this new design analysis refers to Sections 9.8.1 and 9.8.2 for all other feasibility factors. As discussed in Section 1.2, to estimate the new design installation cost, a factor of 67 percent was applied to the filter media installation cost estimate for existing vessels within this group. Using this factor, the assumed installation costs for the new design LSD 41 vessel group is $47,000, per vessel. The projected total initial cost for a filter media system aboard these new design vessels is $71,000, per vessel. Table 9-32 summarizes the costs for these new design vessels.

Table 9-32. TOC for Filter Media on New Design Vessels (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	71	71	71	71
Total Recurring	9.16	9.16	9.16	9.16
TOC (15-yr lifecycle)	80	80	80	80
Annualized	6.8	6.8	6.8	6.8

9.9 MEMBRANE FILTRATION

The following sections discuss the feasibility and cost impacts of installing and operating a membrane filtration [ultrafiltration (UF)] unit on-board a MCM 1 Class vessel.

9.9.1 Practicability and Operational Impact Analysis – Existing Vessels

The polishing unit consists of UF membranes and is designed to treat OWS effluent before being discharged overboard. This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of membrane UF.

9.9.1.1 Space and Weight

The 5-gpm UF unit was selected as the secondary MPCD due to its ability to match capacity requirements of the current MPCD oil/water separator and because the unit was developed specifically for Navy vessels. The Navy expects this capacity to be sufficient for processing the amount of bilgewater generated within 12 nm where an effluent with low oil concentration is most critical. Once beyond 12 nm, the vessel will operate its primary OWS and continue to operate in compliance with regulatory requirements. Table 9-33 summarizes the space and weight of a 5-gpm unit.

Table 9-33. UF Membrane Specifications (MCM 1 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	5 gpm	7x5x6.5	7 x 5 x 6.5	227.5	2500
Total (To achieve required processing capacity)	1	5 gpm	-	-	227.5	2500

Because the MCM Class is in weight critical status (i.e., the initial design margin for accommodating additional weight from new equipment is almost completely used), each individual vessel within the class will have to be analyzed to determine whether it can support a secondary MPCD (Navy, 2000).

9.9.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with membrane systems. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use. Standard afloat control and management procedures are adequate for use and disposal of the material. While membrane systems require electrical power and operate under high pressures, observing standard shipboard safety procedures for handling electrical equipment and pressurized systems should be adequate. A Failure Mode, Effects and Criticality Analysis (FMECA) was generated for the UF system installed on the USS CARNEY (DDG 64). The FMECA lists potential system failures according to their relative probability of occurrence, identifies safety hazards resulting from those failures, and recommends safety practices to reduce the associated safety risk. Applicable safety practices recommended by the FMECA will likely be implemented in conjunction with UF system installation on-board MCM 1 Class vessels.

9.9.1.3 Mission Capabilities

MCM 1 Class vessels are designed to detect and clear mines. Certain mine designs rely on detection of a magnetic signature to trigger detonation. The mine can sense the proximal presence of a ship's magnetic ferrous (steel) hull and detonate itself to cause blast damage to the ship. For this reason, the MCM 1 Class hull is constructed of wood. To further ensure that the magnetic signature of the MCM 1 Class vessel is minimized, certain pieces of equipment that are installed on the ship must meet a magnetic permeability specification (i.e., 2.0 μ). Therefore, equipment must be constructed of materials such that its relative magnetic permeability does not exceed the specification. This consideration only applies to the two mine hunter/mine sweeper classes, MCM 1 and MHC 51, in this vessel group. The other vessels in this group do not have this requirement. The UF system has not been tested in order to ensure its magnetic permeability is within specification. If the tests show the UF system to have a magnetic permeability greater than two, the unit may have to be redesigned using a larger percentage of non-ferrous materials so that is does not impact the ship's mission.

9.9.1.4 Personnel Impact

It is assumed that because a secondary OWS unit runs in conjunction with a primary OWS unit, the secondary unit will not require significant additional oversight. Therefore, operator oversight hours associated with secondary units are assumed to be zero.

The waste oil removed from the bilgewater by the UF system must be transferred to a shore facility. This transfer requires three crewmembers per event as described under Section 9.1.1.4. The labor hours associated with oversight of transfer of waste oil produced within 12 nm by a UF system on MCM 1 are calculated by dividing the waste oil volume (1 percent of the UF effluent volume generated while operating within 12 nm of shore, i.e., 269.3 gal) by the waste oil pump rate (18 gpm) and multiplying by the number (three) of crewmembers.

$$\frac{269.3\,\text{gal}}{\text{yr}} \bullet \frac{\text{min}}{18\,\text{gal}} \bullet \frac{\text{hr}}{60\,\text{min}} \frac{3\,\text{hrs labor}}{\text{hr}} = 0.75\,\text{hrs/yr}$$

The annual labor requirement oversight is .75 hours for offloading waste oil generated within 12 nm.

Annually, the UF system requires approximately 9.3 personnel hours of time-based maintenance, .51 personnel hours of condition-based maintenance within 12 nm, and 0 personnel hours of condition-based maintenance beyond 12 nm. Table 9-34 and Table 9-35 summarize the time-based maintenance and the condition-based maintenance requirements, respectively, for a UF system.

Table 9-34. UF Membrane Time-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Clean and inspect permeate flow sensor	0.2	3 Months	0.8
Clean and inspect recirculation loop temperature sensor	0.2	3 Months	0.8
Clean and inspect continuous level transducer	0.2	6 Months	0.4
Clean and inspect high level sensor probe	0.2	6 Months	0.4
Calibrate pressure gauges	1.0	12 Months	1.0
Clean and inspect recirculation pump suction valve	1.8	12 Months	1.8
Clean membranes (no MRC; for scheduling only. Perform CLEAN cycle. Perform quarterly and when membrane resistance is greater than 100% as indicated on the control panel)	0.1	3 Months	0.4
Clean and inspect membrane system control panel	1.6	6 Months	3.2
Inspect membrane system grounding straps	0.1	12 Months	0.1
Perform lamp test of membrane system control panel; measure insulation resistance.	0.1	3 Months	0.4
Total Annualized Hours	-	-	9.3

Table 9-35. UF Membrane Condition-Based Maintenance (MCM 1 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on 90 operation hours within 12 nm)	Annualized Maintenance Hours (based on 162 operation hours beyond 12 nm)
Replace membranes (accomplished shoreside)	3	2400	.11	0
Drain membrane system	1	600	.15	0
Fill membrane system with water	1	500	.18	0
Replace feed pump mechanical seal. Inspect internal parts	2.5	10000	0.02	0

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on 90 operation hours within 12 nm)	Annualized Maintenance Hours (based on 162 operation hours beyond 12 nm)
Replace recirculation pump mechanical seal. Inspect internal parts	5	10000	0.05	0
Total Annualized Hours	-	-	.51	0

Table 9-36 provides the annual labor hours required to operate and maintain the MPCD proposed in this section.

Table 9-36. UF Membrane Annual Labor Hours (MCM 1 Class)

	MPCD Option: Membrane Filtration
Operator Hours Within 12 nm	0.75
Operator Hours Beyond 12 nm	0
Condition-based Maintenance Within 12 nm	.51
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance Within 12 nm	9.3
Time-based Maintenance Beyond 12 nm	0
Total Time	10.6

9.9.1.5 Consumables, Repair Parts, and Tools

On vessels equipped with the UF system, membranes are scheduled to be replaced after approximately 2400 hours of use. At this time, a new, clean set of membranes are put in the UF system and the old, used ones are sent to shore to be cleaned. This regular maintenance does not require any consumables, as the membranes are exchanged. Furthermore, no special tools are required to operate or maintain the units.

9.9.1.6 Interface Requirements

Table 9-37 summarizes the interface requirements for the UF system. These requirements are not expected to have a substantial impact on the MCM 1 Class vessels.

Table 9-37. UF Membrane Interface Requirements (MCM 1 Class)

Shipboard System	Interface Requirement (10-gpm system)
Electric Power	440 Volts/3 Phase/ 60Hz
Compressed Air	80 to 100 psi, 5 scfm (operate valve actuators)
Potable Water	Fresh water back flush of membranes 10 gpm, 30 psi
Drainage	Concentrate from Recirculation Sub-system drains to WOT. When back flushing membranes, oily waste flushed from system is diverted to OWHT.

MCM 1 Class vessels are able to accommodate these interface requirements.

9.9.1.7 Control System Requirements

The UF system operates automatically in response to the primary OWS operation. Therefore, the UF system does not have any unique control system requirements.

9.9.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

9.9.2 Cost Analysis – Existing Vessels

The following cost data and calculations are provided to allow the reader to compare relative costs associated with a UF system on the MCM 1 Class vessel.

9.9.2.1 Initial Cost

The system (i.e., one unit) procurement cost is $200,000 per vessel (Smith, 1999). However, if the UF system fails to meet the magnetic permeability specifications required by the MCM 1 and MHC 51 vessel classes, the additional cost required to redesign the system may significantly increase its procurement cost. Based on ship arrangement drawing analysis and a MCM 11 (MCM 1 Class vessel) ship check, the Navy estimates that installation will cost $200,000 per vessel (Navy, 2000). Technical manuals cost approximately $85,000 ($6,071 per vessel) to develop a 150-page manual (Gallagher, 1999). The Navy estimates that the development of technical drawings will cost $39,610 ($2,829 per vessel) (Navy, 2000). The cost for training materials is approximately $9,330 ($666 per vessel) (Smith, 2001). The initial cost of a UF system on an MCM 1 Class vessel is $410,000 per vessel.

9.9.2.2 Recurring Cost

The UF system requires 10.6 personnel hours per year for operation, condition-based maintenance, and time-based maintenance within 12 nm, as explained under Section 9.9.1.4. The annual labor hours multiplied by the $22.64 per hour MPCD operator labor rate produces the first operating year recurring labor cost of $239.

$$\frac{\$22.64}{\text{yr}} \bullet \frac{10.6 \text{ hrs}}{\text{yr}} = \$239/\text{yr}$$

The labor required to transfer waste oil generated by the UF membrane system to a disposal facility is included in the above labor cost estimates. As explained in Section 1.1.2, the disposal facility is assumed to dispose of the waste oil at no charge for Navy vessels.

Coast Guard vessels pay a fee to dispose of their waste oil. The recurring cost incurred by the Coast Guard to dispose of the waste oil generated within 12nm is shown below.

$$\frac{269.3\,\text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$245/\text{yr}$$

Table 9-38 summarizes the annual recurring costs for UF systems on an MCM 1 Class vessel.

Table 9-38. Annual Recurring Costs for UF System (MCM 1 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	0.239
Beyond 12 nm	Navy	-
Within 12 nm	Coast Guard	0.484
Beyond 12 nm	Coast Guard	-

9.9.2.3 Total Ownership Cost (TOC)

Table 9-39 summarizes the TOC and annualized cost over a 15-year lifecycle for a UF system on a MCM 1 Class vessel.

Table 9-39. TOC for UF System (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	410	410	410	410
Total Recurring	2.66	2.66	5.39	5.39
TOC (15-yr lifecycle)	413	413	415	415
Annualized	35.1	35.1	35.3	35.3

9.9.3 Practicability and Operational Impact Analysis – New Design Vessels

The practicability and operational impact of using UF membrane systems on new design vessels in this vessel group are expected to be similar to the impact on existing vessels in this group, as represented by MCM 1 Class vessels.

9.9.4 Cost Analysis – New Design Vessels

The installation cost would be different for new design vessels; however, all other costs are not expected to change. Therefore, except for the installation cost and the adjusted TOC, this new design analysis refers to Sections 9.9.1 and 9.9.2 for all other feasibility factors. As discussed in Section 1.2, to estimate the new design installation cost, a factor of 67 percent was applied to the UF membrane system cost estimate for existing vessels within this group. Using this factor, the assumed installation costs for the new design MCM 1 vessel group is $134,000, per vessel. The projected total initial cost for a UF system aboard these new design vessels is $344,000, per vessel. Table 9-40 summarizes the costs for these new design vessels.

Table 9-40. TOC for UF Membrane System on New Design Vessels (MCM 1 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	344	344	344	344
Total Recurring	2.66	2.66	5.39	5.39
TOC (15-yr lifecycle)	346	346	349	349
Annualized	29	29	30	30